

CONTRACT TR413

**REPLACEMENT OF TRAFFIC AND COMMUNICATIONS SYSTEM
FOR KALLANG-PAYA LEBAR EXPRESSWAY AND MARINA COASTAL
EXPRESSWAY**

TECHNICAL SPECIFICATION

ATTACHMENT B

COMMUNICATIONS SYSTEM

TECHNICAL SPECIFICATION

COMMUNICATIONS SYSTEM

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COMMUNICATIONS SYSTEM

1 GENERAL

- 1.1 This Specification defines the works and requirements for the renewal of the Communications System for KPE and MCE under Contract TR413.
- 1.2 The requirements for the new Communications System for KPE and MCE (referred to as "COMMS" hereafter) are described in this Specification.
- 1.3 "COMMS" shall refer to the communications system that are renewed under TR413. "Existing COMMS" or "existing COMMS" shall refer to the existing communications system that are not renewed under TR413.

2 SCOPE OF WORK

- 2.1 The Contractor shall design, supply, deliver, install, test and commission the following systems and equipment for COMMS:
 - (a) Communications Backbone Network (CBN) for KPE and MCE;
 - (b) FM radio Re-Broadcast & Break-in (FM RBBI) System for KPE and MCE;
 - (c) Clock System for KPE and MCE;
 - (d) Integrated Voice Recording System (IVRS) for KPE and MCE;
 - (e) Communications Power Supply System for KPE; and
 - (f) New Servers and Workstations for the following systems for KPE and MCE:
 - (i) Ventilation Building Public Address System (VB_PA)
 - (ii) Tunnel Public Address System (T_PA)
- 2.2 The Contractor shall be responsible for all provisions required for the implementation and operation of the COMMS as specified in this Specification, which shall include but not limited to the following:
 - (a) All equipment including field devices, enclosures, racks, mounting accessories, etc.
 - (b) All software and firmware including licences.

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- (c) All power distribution works including electrical breakers, distribution boards, etc.
- (d) All cables, cable supports, enclosures, mounting accessories, main distribution frames, optical distribution frames, etc.
- (e) Modification, configuration, upgrading, etc. of existing communications system where required for the Works.
- (f) Interface and integration of COMMS with existing systems and interfacing systems supplied by others where required for the Works.
- (g) Prepare and submit complete documentation including design submissions, drawings, compliance matrices in compliance with all relevant technical and contractual requirements to the SO for acceptance. This shall include the preparation and submission of all design/plans as may be required to relevant authorities for approval. Drawings shall include new drawings to be produced and updates to existing as-built drawings on all affected systems.
- (h) Testing and commissioning of COMMS, including interface and integration tests with existing systems and interfacing systems supplied by others.
- (i) Decommissioning, removal and disposal of all equipment and cables made redundant by the Works.

- 2.3 The Contractor shall note that details of the existing communications system architecture, schematic diagrams, technical details are shown in Appendices B-2 to B-17. For information pertaining to existing systems, the Contractor shall conduct site surveys to verify the accuracy and sufficiency of the information provided for the Works.
- 2.4 The Contractor shall ensure that all equipment supplied shall be fully compatible with the existing systems including systems that are provided by the Employer's maintenance contractor/Interfacing Parties (refer to **Schedule D** of Particular Specification).
- 2.5 The Contractor shall ensure that modifications to, as well as integration and interfaces with the existing systems are carried out with minimum disruption to operations subject to the acceptance of the Superintending Officer (SO).
- 2.6 The Contractor shall be responsible for all works and provisions that are required for the progressive migration of the existing systems to the new systems. During the migration works, the existing and new systems shall interoperate seamlessly without degradation and interruption deemed unacceptable to operations. The Contractor shall produce method

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statements, migration strategies and plans for the migration works, which shall be subjected to the acceptance of the SO.

- 2.7 The Contractor shall take into consideration and make provisions for , temporary staging/set-up, etc., where required to facilitate the migration works. All temporary provisions are to be proposed by the Contractor, and subject to the acceptance of the SO.
- 2.8 The Contractor shall ensure no degradation to the performance of the COMMS and associated systems after the integration with the existing systems. This shall include all existing system functionalities and features, etc.
- 2.9 The Contractor shall ensure that all hardware and software supplied shall be based on proven systems. All software licenses shall be provided by the Contractor. All hardware and software shall be of the latest version as of six (6) months before the Factory Acceptance Test (FAT).
- 2.10 The Contractor shall be responsible for the modification of existing systems including cabling works as required for the Works. All works described in the Specification are only indicative. The exact extent and scope of modification required shall be determined and proposed as part of the Contractor's design in coordination with the Interfacing Parties during the project implementation phase.
- 2.11 The Contractor shall be responsible for the removal and reinstatement of tunnel claddings for the Works. The Contractor shall refer to **Clause 11.6.12** of Particular Specification.
- 2.12 The Contractor shall liaise and co-ordinate directly with other relevant authorities such as the Info-communications Media Development Authority of Singapore (IMDA), etc, and be responsible for applying and obtaining all approvals, licenses, permits and leased lines for the Works where required. All costs associated with the applications, usage, subscriptions, equipment and tests necessary to obtain such approvals and services shall be borne by the Contractor until end of Defects Liability Period (DLP).
- 2.13 Unless otherwise specified, the Contractor shall make provision of all mounting support, power distribution, etc., installation accessories where required for the Works as stipulated in this Specification.
- 2.14 Within COMMS, the response time of indicating a single operator command shall be within 1 second from the last command button pressed at workstations to their respective MMI display.

3 COMMUNICATIONS SYSTEM (COMMS)

3.1 General

3.1.1 The COMMS shall comprise the following systems and equipment:

- (a) Communication Backbone Network (CBN) for KPE and MCE;
- (b) FM radio Re-Broadcast & Break-in (FM RBBI) System for KPE and MCE;
- (c) Clock System for KPE and MCE;
- (d) Integrated Voice Recording System (IVRS) for KPE and MCE;
- (e) Communications Power Supply System for KPE; and
- (f) New Servers and Workstations for the following systems for KPE and MCE:
 - (i) Ventilation Building Public Address System (VB_PA)
 - (ii) Tunnel Public Address System (T_PA)

3.1.2 A summary of the existing KPE and MCE equipment makes and models is provided in Appendix B-16 for reference only.

4 COMMUNICATIONS BACKBONE NETWORK (CBN)

4.1 General

4.1.1 This section defines the works and requirements for the new CBN.

4.1.2 The purpose of the CBN is to carry voice and data traffic for the systems between Main OCC, Standby OCC and the ventilation buildings of KPE and MCE.

4.1.3 The existing CBN comprises the following equipment installed at the Ventilation Buildings (VBs):

Equipment	MCE		KPE					
	VB2	VB1	VBA	VBB	VBC	VBD	VBE	VPF
STM-4	1	2	1	2	1	3	1	1
NMS		1				1		

4.1.4 The existing CBN provides independent access paths to support the following existing Communications sub-systems:

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- (a) FM radio Re-Broadcast and Break-In (FM RBBI) System;
- (b) Ventilation Building PA System (VB_PA);
- (c) Tunnel PA System (T_PA);
- (d) Expressway Emergency Telephone System (EETS); and
- (e) Public System Branch Exchange (PABX).

4.1.5 The existing CBN also support the existing OA LAN system.

4.1.6 The existing Communications sub-system interfaces with the existing CBN via Gigabit Ethernet (GBE) switches installed at the VBs as shown below:

Equipment	MCE		KPE					
	VB2	VB1	VBA	VBB	VBC	VBD	VBE	VBF
GBE Switches	2	2	1	3	1	5	1	1

4.1.7 The existing KPE and MCE CBN (including GBE switches) system architecture diagram is provided in Appendix B-2 for reference only. The existing traffic loading for the CBN is also provided in Appendix B-13(a) for reference only.

4.2 Scope of Work

4.2.1 The Contractor shall be responsible but not limited to the following works:

- (a) Replacement of existing SDH CBN nodes at KPE and MCE, i.e. VB1, VB2, VBA, VBB, VBC, VBD, VBE and VBF, with new MPLS-TP CBN nodes.
- (b) Replacement of existing Network Management System (NMS) at VBD and VB1 with new NMS.
- (c) Replacement of all other associated devices, i.e., network equipment and devices, workstations, servers, etc.
- (d) Provision of new maintenance laptop including all necessary software for the new CBN.
- (e) Replacement of existing GBE switches at KPE and MCE, i.e. VB1, VB2, VBA, VBB, VBC, VBD, VBE and VBF, with new GBE switches.

4.3 Concept of Operation

- 4.3.1 The concept of operation for the existing CBN as well as the new CBN is indicated / shall be as follows respectively:

	Existing	New
CBN NMS	The main and standby NMS operates in a redundant configuration. The standby NMS takes over seamlessly when the main NMS fails.	Shall be similar as the existing operation.
CBN Nodes	The existing CBN comprises 12 nodes as shown in Appendix B-2.	The new CBN shall consist of 10 nodes as shown in Appendix B-4. The CBN traffic for the existing communication sub-systems and the OA LAN shall be migrated over and re-configured as per the new CBN. The new CBN shall support the traffic requirements of the new sub-systems/equipment of COMMS as per the traffic allocation indicated in Appendix B-13(b).
GBE Switches	The existing GBE switches comprises 16 switches as shown in Appendix B-2.	The new GBE switches shall connect the existing communications sub-systems and the new sub-systems/equipment of COMMS to the new CBN as per the traffic allocation indicated in Appendix B-13(b). Where CBN independent access paths are required, separate GBE switches shall be provided for redundancy.

- 4.3.2 A summary of new CBN equipment and new GBE switches that shall be supplied by TR413 is specified in Appendix B-1.

4.4 Design Requirement

- 4.4.1 The CBN shall be based on Multi-Protocol Label Switching Transport Profile (MPLS-TP) technology defined by the International Telecommunication Union – Telecommunication (ITU-T) and/or Internet

Engineering Task Force (IETF) recommendations and standards. It shall be designed with standard-based interfaces as defined by the ITU-T and/or the IETF to support high speed data communications. Fibre optic cables and cable accessories shall form part of the overall CBN.

- 4.4.2 As a minimum, the CBN node shall be able to support all voice, data and video traffic, including time-division multiplexing (TDM) as well as Ethernet based traffic of the interfacing systems. All fibre optic cables and cable accessories shall form part of the overall CBN.
- 4.4.3 The KPE and MCE CBN shall be equipped as follows:
- (a) All CBN nodes at KPE and MCE shall be live at all times to support the KPE and MCE tunnel operations.
 - (b) In the event of failure of a CBN node, the CBN shall continue to operate seamlessly and to maintain KPE and MCE tunnel operations except for the portion served by that CBN node that fails.
 - (c) In the event of failure of a CBN node, the redundant ring shall takeover and continue to operate seamlessly and maintain the KPE and MCE tunnel operations.
 - (d) The operator shall be notified of any failure via audio and visual prompts at the CBN NMS.
- 4.4.4 All design shall be subjected to the SO's acceptance during the design stage.
- 4.5 System Architecture
- 4.5.1 The Contractor shall provide a new CBN (including new GBE switches) based on the conceptual architecture provided in Appendix B-4 for the operation of KPE and MCE communications system. The Contractor may propose alternative architecture(s) for the new CBN if and only if the alternative architecture(s) do not exceed the no. of nodes and spare fibre cores available.
- 4.5.2 The CBN traffic for the existing Communication sub-systems as well as OA LAN shall be migrated over and re-configured as per the traffic allocation indicated in Appendix B-13(b). The new CBN shall also support the traffic requirements of the new sub-systems/equipment of COMMS as per the traffic allocation indicated in Appendix B-13(b). The Contractor may, subject to the SO's acceptance, propose alternative and more efficient traffic allocation. Such alternative(s) shall not impact the existing/intended operations of the existing Communications sub-systems as well as OA LAN and new sub-systems/equipment of COMMS.

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- 4.5.3 The CBN shall be based on connection-oriented packet-switching technology with traffic-engineering capabilities to allow deterministic control of the use of network resources. As a minimum, it shall support traffic-engineered point-to-point and point-to-multipoint transport paths.
- 4.5.4 Where two (2) independent access points to the CBN are required for the interfacing systems for diversity purposes, these independent paths shall be supported with separate input/output cards to physically protect these paths for the complete end-to-end connection.
- 4.5.5 The CBN shall provide Quality of Service (QoS) to manage bandwidth utilization for each interfacing system, and to optimize the available bandwidth within each CBN ring. The CBN shall be able to provide end-to-end traffic solution with low latency, high availability and carrier class for both linear and ring configurations.
- 4.5.6 There shall be no single point of failure in CBN that will result in the total failure of a CBN ring or the isolation of any CBN node from Main and Standby OCC node(s).
- 4.6 System Capacity and Expansion
 - 4.6.1 CBN shall be designed and equipped to accommodate the following:
 - (a) All necessary traffic requirements for the interfacing systems; and
 - (b) 50% spare capacity with respect to the traffic requirements for the interfacing systems.
 - 4.6.2 The 50% spare capacity shall include all necessary equipment shelf space (including cabling between equipment shelf and distribution panels/frames), channel bandwidths (including the transmission and interface cards) to/from each CBN node, and all software licenses.
 - 4.6.3 As a minimum, the CBN bandwidth provided shall be at least 10 Gbps per ring including 50% design spare. Notwithstanding this, higher capacity CBN shall be installed in the event the bandwidth of 10 Gbps is insufficient to meet the requirements stipulated in Clauses 4.6.1 and 4.6.2.
 - 4.6.4 The activation of the spare capacity shall be achieved without disruption to the operational live traffic.
 - 4.6.5 The channel allocations and types of interfaces for the traffic requirements shall be identified during the design phase and in consultation with the relevant parties.
- 4.7 System Interfaces

4.7.1 As a minimum, the CBN shall support the following set of interfaces:

- (a) Pseudo-wire (PW) and/or TDM Emulations (e.g. E1);
- (b) 1/10 Gbps Ethernet port; and
- (c) 100 Mbps Ethernet port.

4.7.2 All interfacing systems connecting to CBN shall have interface parameters, protocols and interconnecting systems that are based on common standards. All interface circuitries and signalling on the CBN interfaces shall be fully compatible with and are able to support the latency requirements of the interconnecting systems. The CBN shall be equipped to support any additional traffic capacity requirements as required during the design phase.

4.7.3 The CBN shall isolate and segment traffic for individual system(s) within a CBN ring (i.e. individual Virtual Local Area Network). Point-to-point and/or point-to-multiple points connections within the CBN ring or between multiple CBN rings (if required) for each interfacing system shall be provided where required by the design.

4.8 Protection and Redundancy

4.8.1 The CBN shall provide 100% protection of the traffic on the protected paths.

4.8.2 The CBN shall support configuration of protection paths and protection-to-working path relationships.

4.8.3 The CBN shall guarantee that the switching from working to protection paths, from the time of fault detection to the completion of protection switching shall take no more than 50ms.

4.8.4 Ring configuration shall conform to ring protection specified in ITU-T G.8032/Y.1344 recommendations.

4.8.5 The CBN protection switching shall be triggered automatically and shall be carried out on a local basis without any intervention from Network Management System (NMS) or operator. Protection switching shall not be achieved by downloading reconfiguration data onto remote nodes. All such switching and fault identifications shall be reported to the CBN NMS.

4.9 Module Redundancy

- (a) All critical modules shall be protected with redundancy.
- (b) Critical modules shall comprise, but not be limited to the following:

- (i) Power supply modules;
- (ii) Processor and switching modules; and
- (iii) Traffic modules.

4.9.1 Each CBN node and network device shall be supported with dual input power source with 1+1 power module redundancy. Failure of any input power source or power module shall not degrade or affect the operation and performance of the CBN node. One of the power modules shall be connected to the UPS source while the other power module shall be connected to the non-UPS source.

4.9.2 CBN node shall be provided with hot-swap capability. The removal/disconnection, addition/connection or replacement of any modules or cards on the CBN node shall not cause any reboot, shut down or interruption to the traffic, services and proper operation of the CBN node.

4.10 Network Performance

4.10.1 Performance of CBN circuits shall conform to all relevant ITU-T or IETF recommendations and standards.

4.10.2 CBN shall conform to Carrier-Class packet transport for the following areas:

- (a) Standardized Services;
- (b) Scalability;
- (c) Reliability;
- (d) Quality of Service (QoS); and
- (e) Service Management.

4.10.3 The CBN shall be able to create the following:

- (a) Virtual Bridge Local Area Network conforming to IEEE 8802.1Q;
- (b) E-LINE for point-to-point Ethernet Virtual Connection between two users;
- (c) E-LAN for Ethernet Virtual Connection for Multipoint Connectivity; and
- (d) E-Tree for Rooted-Multipoint Ethernet Virtual Connection.

- 4.10.4 Detailed performance calculations for all traffic types on the network shall be submitted and these performance specifications shall be demonstrated to the SO during system commissioning. A 28-day system stability test shall be conducted by means of monitoring error performance of worst-case traffic channels over the 28-day period. During this period, there shall be no error bursts or protection switching events.
- 4.11 Synchronisation
 - 4.11.1 The Contractor shall produce an overall synchronisation plan for the CBN design. The synchronisation shall be based on Synchronous Ethernet (SyncE) in accordance with ITU-T G.8262/Y.1362 recommendations or Precision Time Protocol (PTP) clock source in accordance with IEEE 1588v2.
- 4.12 Transmission Equipment
 - 4.12.1 The optical transmitter shall be designed to operate such that a break in the fibre routes shall cause the associated laser to shut down automatically to a safe level as defined in IEC-60825.
 - 4.12.2 Link budget calculations shall be included for all optical links in the CBN.
 - 4.12.3 The system configuration including card settings shall not be lost in the event of power interruption or failure and system reset.
- 4.13 Requirement for Standby OCC
 - 4.13.1 The CBN shall be sufficiently designed and equipped such that all VBs shall always be linked to both Main and Standby OCC during normal operation.
 - 4.13.2 The CBN provisions shall also include all necessary CBN nodes, interfaces and bandwidth to link up Main and Standby OCC for the synchronisation, monitoring, control and testing functions of the respective systems.
 - 4.13.3 The CBN connectivity for Standby OCC shall be such that fully protected paths between the VBs and the Standby OCC shall still be maintained when the Main OCC CBN nodes are down. Similarly, the CBN connectivity for the Main OCC shall not be affected if Standby OCC's CBN nodes are down.
- 4.14 Operation, Administration and Management for MPLS-TP
 - 4.14.1 The following Operation, Administration and Management (OAM) functions for MPLS-TP shall be provided:

(a) Fault Management Functions

- (i) Continuity Check Message (CCM): Provide continuity check on OAM messages to detect loss of continuity or incorrect network connections.
- (ii) Loopback Message (LBM): Send loopback message to verify connectivity.
- (iii) Alarm Indication Signal (AIS): Provide alarm suppression so that an NMS does not receive an excessive number of redundant alarms for a particular fault. It shall inform operators that a network path and/or a service instance has failed.
- (iv) If a defect/fault occurs on a PW, Label Switched Path (LSP) or section, mechanism(s) shall be provided to detect, diagnose and localize the defect/fault, as well as notify the appropriate node(s).

(b) Performance Management Functions

- (i) Frame Delay (FD): Measure FD, which is defined as the time elapsed since the start of transmission of the first bit of the frame by a source node until the reception of the last bit of the loop backed frame by the same source node.
- (ii) It shall provide diagnostic tests on the PW, LSP or section.

4.15 Quality of Service (QoS)

4.15.1 The CBN shall be provided with advanced traffic management capabilities to enforce and guarantee the QoS parameters determined by the respective sub-systems.

4.15.2 QoS mechanism shall be provided to ensure prioritization of services, to guarantee bandwidth, and to control jitter and delay so as to meet QoS requirements of the interfacing systems. CBN shall be able to provide service monitoring in order to verify the delivery of an agreed QoS. This shall be made possible by means of carrier grade CBN node.

4.15.3 The following QoS mechanism shall be provided:

- (a) Support for differentiation of services and traffic types with traffic class separation associated with different traffic.
- (b) Enabling the provisioning and guarantee of Service Level Specifications with support for hard and relative end-to-end bandwidth guaranteed.

- (c) Support of services, which are sensitive to jitter and delay.
- (d) Guarantee of fair access within a particular class to shared resources.
- (e) Capability to effectively support service demands over CBN. This shall include support for a flexible bandwidth allocation scheme.

4.16 CBN Network Management System (NMS)

4.16.1 CBN NMS shall be provided and operated in both Main and Standby OCC. Both NMS shall be synchronized and be always connected to and be updated on every CBN node's operating status e.g. alarms. Both NMS shall be able to communicate with every CBN node in the network. The NMS at the Standby OCC shall automatically take over the function of the Main OCC NMS in the event of its failure.

4.16.2 CBN NMS shall be equipped with the following management functions:

(a) Performance Management

Performance management system shall be able to monitor basic network performances (e.g. bring-into-service, statistics gathering and checking of QoS) including all OAM functions. It shall be able to collect and store measurement data from all CBN nodes for post measurement analysis, data processing of the entire network including the management of optical network signals.

(b) Fault Management

Fault management system shall be able to monitor real-time alarm status from all CBN nodes to the entire network. It shall perform supervision, detection, validation, isolation, correction, and reporting of abnormal operation of the entire network and its environment. The CBN shall provide supervision of the OAM mechanism(s) that are deployed for OAM requirements. It shall support the ability to assign severity (e.g. critical, major, minor, warning) to alarm conditions via configuration. It shall support alarm reporting of relevant events and conditions which occur in the network. All alarms shall be monitored via graphical user interface (GUI) and allow users the flexibility to define all alarm monitoring criteria.

(c) Configuration Management

(i) Configuration management system shall be able to:

(l) Identify, collect data from CBN nodes;

- (II) Provide data to CBN nodes;
 - (III) Control CBN nodes, including hardware and software configuration, configuration of CBN nodes to support transport paths (including required working and protection paths), and configuration of required path integrity/connectivity/protection information (e.g. create, modify and/or delete end-to-end connections with the ability to create 1+1 and/or 1:1 protected paths) and performance monitoring (i.e. OAM);
 - (IV) Support configuration of the OAM entities and functions; and
 - (V) Generate output configuration information of any circuit or group of circuits to NMS. This output shall be available in printable and soft copy.
- (d) Security Management
- (i) Security management system shall be able to:
 - (I) Manage user administration, such as, user creation, deletion, setting and changing of multi-level password for the administrator and operator access purpose;
 - (II) Provide and manage user access privileges and defining user profiles;
 - (III) Protect all data held within the NMS (e.g. data for network configuration) from unauthorised access; and
 - (IV) Restriction of access shall be achieved through the use of user ID and password identifier. This identifier shall be associated with a defined set of allowable actions which shall restrict the user to his pre-defined areas of activities.

4.16.3 The CBN NMS shall allow the operators to perform end-to-end management. Proper database management functions shall be provided for the user to perform sorting of event log, searching of event by dates or alarm type and printing of specific event log into hardcopy or softcopy. The alarms and event logs shall be kept within CBN NMS for a period of at least (6) months. CBN NMS shall be equipped with facility to allow archival of these logs to external storage media or devices.

4.16.4 The CBN NMS shall display in graphical format the health status of the overall network configuration at the default application layer. CBN NMS shall have "point and click" zooming function that will provide access to

detailed network information from top level display of the overall network down to the node level and to the card level within equipment racks. CBN NMS shall have means to display a geographical overview of the entire network in which CBN nodes and its associated VBs can be identified by location names. The name of each VBs shall be configurable by the operator.

- 4.16.5 Failure of CBN NMS system shall not in any way affect the functionality and normal operation of the CBN. All traffic requirements provided for the operation of the entire system shall remain fully operational in case of CBN NMS failure. Loss of power or power fluctuation at CBN NMS shall not result in corruption of CBN NMS database.
- 4.16.6 CBN NMS shall allow operators to define alarm classifications. By default, there shall be four main alarm classifications, namely critical, major, minor, warning alarms.
- 4.16.7 Digital recording media shall be provided for backup of the entire CBN configuration and CBN NMS database information. Proper restoration procedures shall be established to allow operators to restore the means to restore the configuration and the database of the NMS. CBN NMS shall be able to initiate automatic saving of the CBN configuration and the database information upon activation of a pre-assigned backup interval. The database shall remain fully operational during on-line backup process.
- 4.16.8 As a minimum, alarms shall be provided for all critical modules including the failure of processor, switching modules, controller modules, traffic modules, power modules, etc.
- 4.16.9 CBN alarm monitoring shall be configurable based on alarm criticality.
- 4.16.10 Any changes in computer hardware technology shall not affect the functionalities of the CBN NMS. The operating system and CBN NMS software shall be sufficiently independent from computer hardware such that any upgrade to the hardware shall not require any CBN NMS software modification.
- 4.16.11 Portable maintenance laptop shall be provided for monitoring, log/event retrieval and setting to work of the CBN. The portable maintenance laptop shall contain all local node management functions similar to that of CBN NMS as described in Clause 4.16.2.
- 4.17 Gigabit Ethernet (GBE) Switches
 - 4.17.1 GBE switches shall be based on Gigabit Ethernet (GBE) technology and be equipped with all necessary network interface modules and power supply modules to support the new CBN and the interfacing Communications sub-systems.

- 4.17.2 Ethernet NMS shall be provided to manage and monitor all traffic and network connectivity on the GBE switches. The Contractor shall provide two (2) nos. of Ethernet NMS with 1 no. at Main OCC and 1 no. at Standby OCC.
- 4.17.3 Ethernet NMS shall be able to manage basic user administration, such as, user creation, deletion, setting and changing of multi-level password for the administrator and operator access purpose. All data held within the NMS (e.g. data for network configuration) shall be protected from access by unauthorised users. The restriction of access shall be achieved through the use of user ID and password identifier. This identifier shall be associated with a defined set of allowable actions which shall restrict the user to his pre-defined areas of activities.
- 4.17.4 All alarms shall be monitored and reported to the Ethernet NMS. All alarm information shall enable quick identification of the fault and its source. Ethernet NMS shall be able to see the health and performance of the network.
- 4.17.5 The Contractor shall also install the Ethernet NMS software application in the portable maintenance laptop provided in Clause 4.16.11.
- 4.18 Interface Requirement
- 4.18.1 An overall synchronisation plan shall be provided for the CBN and the new Clock System.
- 4.18.2 The CBN shall acquire its timing signal from the new Clock System and shall be equipped to accept dual sources. Switching from one clock source to the other clock source shall be carried out automatically without any intervention of NMS or the operator.
- 4.18.3 The new CBN shall interface with KPE-MCE ITPMS 1.0 and KPE-MCE ITPMS 2.0 for alarms and operating status management as stipulated in:
- **Clause 16** of Particular Specification; and
 - **Attachment E** of Technical Specification.
- 4.19 Existing Fibre Optic Cables
- 4.19.1 The existing CBN utilises the existing CBN fibre optic cores at KPE and MCE. The Contractor shall re-use these existing CBN fibre optic cores for the implementation of the new CBN. The number of spare fibre optic cores that are available are indicated in Appendix B-3.
- 4.20 Migration Requirement

- 4.20.1 Prior to the CBN migration works, the Contractor shall put to service the new CBN ring and GBE switches using the existing available spare fibre cores. The new and the existing CBN shall co-exist during the period of the CBN migration to allow for minimum disruption to operations. The Contractor shall ensure the stability of the new CBN before proceeding with the migration of all existing traffic from the existing CBN to the new CBN.
- 4.20.2 The migration and testing of the new CBN shall be carried out in stages until all the sub-system traffic have been successfully migrated.
- 4.20.3 Pre and post migration checks shall be performed to ensure that all systems are functioning normally subject to the acceptance of the SO.

5 FM RADIO RE-BROADCAST & BREAK-IN (RBBI) SYSTEM

5.1 General

5.1.1 This section defines the works and requirements for the new Frequency Modulation (FM) radio Re-Broadcast and Break-In (RBBI) system.

5.1.2 The purpose of the FM RBBI system is to provide:

- (a) FM rebroadcast for the transmission of “off-air” FM radio station signal into the tunnels.
- (b) Audio break-in of live and pre-recorded messages in Main and Standby OCC for making announcements to users in the tunnels.

5.1.3 The existing FM RBBI system comprises the following equipment installed at the VBs:

Equipment	MCE		KPE					
	VB2	VB1	VBA	VBB	VBC	VBD	VBE	VBF
Backend System (FM Processor)	1	1		1				
FM RBBI workstation		2				2		
In-tunnel Broadcast Monitoring System (IBMS)	1	1		1				

5.1.4 The existing backend system for the FM RBBI system comprises processors, modulators, de-modulators, controllers, servers, etc. for control and management of the FM RBBI system.

- 5.1.5 The existing FM RBBI system also comprises the following equipment installed in tunnel niches:

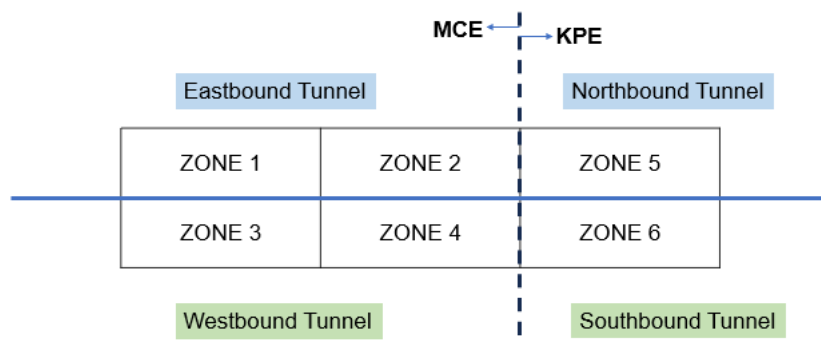
Equipment	MCE	KPE
UDA (Eastbound/Northbound)	2	13
UDA (Westbound/Southbound)	2	13

- 5.1.6 The existing FM RBBI system uses the following existing fibre optic cables:

S/N	Existing Fire-Resistant Fibre Optic cables for FM RBBI system	Number of FO Cores
1	VB2 to Niche (Eastbound)	2 core
2	VB2 to Niche (Westbound)	2 core
3	VB1 to Niche (Eastbound)	2 core
4	VB1 to Niche (Westbound)	2 core
5	VBB to each of the Niche (Northbound) (Total 13 locations)	2 core
6	VBB to each of the Niche (Southbound) (Total 13 locations)	2 core
7	VB1 to VB2	4 core

- 5.1.7 The existing FM backend system at VBB provides FM rebroadcast into KPE while the existing FM backend systems in VB1 and VB2 provides FM rebroadcast into MCE.

- 5.1.8 There are a total of six (6) existing FM zones as illustrated in the diagram below:



- 5.1.9 The existing RF infrastructure comprises of combiners, Low Loss Coaxial (LLC) cables, leaky coaxial (LCX) cables, etc. that carries the operation and maintenance (O&M)/SCDF radio signals and FM RBBI signals to facilitate road tunnel operations and maintenance, as well as for SCDF

personnel for their normal and incident response operations in road tunnels.

5.1.10 The existing KPE and MCE FM RBBI system architecture diagrams are provided in Appendix B-5 and Appendix B-6 for reference only.

5.1.11 The typical KPE and MCE tunnel niche and UDA diagrams are provided respectively in Appendix B-10 and Appendix B-11 for reference only.

5.2 Scope of Work

5.2.1 The Contractor shall be responsible but not limited to the following works:

(a) At MCE VB1

- (i) Replacement of existing set of FM RBBI system with new FM RBBI system including new IBMS.
- (ii) Replacement of existing FM RBBI workstations with new FM RBBI workstations in the MCE OCC.
- (iii) Lay 26 nos. of new fire-resistant fibre optic cables (with 12 cores each) from VB1 to 26 nos. of KPE tunnel niches (see Appendix B-7) complete with new ODFs and all necessary FO accessories in each VB.
- (iv) Replacement of off-air pick-up antennas and in-tunnel feedback antennas.
- (v) Provision of new FM UDAs for the MCE tunnel section.

(b) At MCE VB2

- (i) Removal and decommissioning of existing set of FM RBBI system including existing IBMS.
- (ii) Provision of new FM UDAs for the MCE tunnel section.
- (iii) Removal and decommissioning of off-air pick-up antennas.

(c) At MCE Tunnels

- (i) Replacement of existing FM UDAs in MCE tunnels with new FM UDAs.

(d) At KPE VBB

- (i) Replacement of existing set of FM RBBI system with new FM RBBI system including new IBMS.

- (ii) Lay 8 nos. of new fire-resistant fibre optic cables (with 12 cores each) as indicated below complete with new ODFs and all necessary FO accessories in each VB:

- VBB to 4 nos. of MCE tunnel niches (see Appendix B-7)
- VBB to MCE VB1 (2 nos. of FO cables) (see Appendix B-7)
- VBB to MCE VB2 (2 nos. of FO cables) (see Appendix B-7)

(e) At KPE VBD

- (i) Replacement of existing sets of FM RBBI workstation with new FM RBBI workstation in KPE OCC.

(f) At KPE Tunnels

- (i) Replacement of existing sets of FM UDAs at KPE tunnels with new FM UDAs.

5.3 Concept of Operation

5.3.1 The concept of operation for the existing FM RBBI system as well as the new FM RBBI system is indicated / shall be as follows respectively:

	Existing	New
FM RBBI System	a) The MCE FM RBBI system provides FM radio RBBI to MCE tunnels only. b) The KPE FM RBBI system provides FM radio RBBI to KPE tunnels only.	a) The MCE FM RBBI system shall provide FM radio RBBI to MCE tunnels as well as KPE tunnels. b) In the event the MCE FM RBBI system is down, the KPE FM RBBI system shall takeover and provide FM radio RBBI to MCE tunnels as well as KPE tunnels. c) The switchover from MCE FM RBBI system to KPE FM RBBI system shall be activated manually by the operators (switchover design to be proposed by Contractor

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		for the SO's acceptance).
	The existing MCE FM RBBI system comprises two (2) nos. of FM backend system at MCE VB1 (1 no.) and VB2 (1 no.). There is one (1) IBMS serving two (2) nos. of FM monitoring zones in MCE VB1. There is one (1) IBMS serving two (2) nos. of FM monitoring zones in MCE VB2. The existing KPE FM RBBI system comprises one (1) nos. of FM backend system at KPE VBB. There is one (1) IBMS serving two (2) nos. of FM monitoring zones in KPE VBB.	The new MCE FM RBBI system shall comprise one (1) no. of FM RBBI backend system at MCE VB1. There shall be one (1) IBMS serving two (2) nos. of FM monitoring zones in MCE VB1. Shall be similar as the existing. Shall be similar as the existing.
FM RBBI Workstation	The Standby OCC FM RBBI workstation is able to perform FM RBBI functions when the Main OCC FM RBBI workstations fail. At any one time, only two FM RBBI workstations in total can be active.	Shall be similar as the existing operation. At any one time, all FM RBBI workstations at Main and Standby OCC shall be active upon login by the operators.

5.3.2 A summary of new FM RBBI system equipment and cables that shall be supplied by TR413 is specified in Appendix B-1.

5.4 System Requirement

5.4.1 The new FM RBBI system shall support the following features:

- (a) FM rebroadcast for twenty-two (22) FM radio channels into the tunnels.

- (b) Audio break-in at KPE and MCE OCCs into KPE and MCE tunnels through the twenty-two (22) FM radio channels.

5.5 Design Requirement

- 5.5.1 The new FM RBBI system shall be fully compliant with all relevant regulations and requirements of the IMDA and all other relevant local standards and regulations for radio communication equipment and services in Singapore.
- 5.5.2 The Contractor shall provide all hardware and software required to support the new FM RBBI workstation audio break-in of pre-recorded and “live” announcement audio break-in from Main and Standby OCC.
- 5.5.3 The operators in the KPE and MCE OCCs shall be able to interrupt all FM radio broadcasts within the tunnels via the audio break-in to provide information or instructions to tunnel users who are tuned in to the supported FM radio stations. Computerised storage system shall be provided as part of the audio break-in facility to store audio messages for emergency broadcasts.
- 5.5.4 All design shall be subjected to the SO’s acceptance during the design stage.

5.6 System Architecture

- 5.6.1 The Contractor shall provide a new FM RBBI system based on the conceptual architecture provided in Appendix B-7.
- 5.6.2 The new FM RBBI system shall leverage on the existing KPE and MCE tunnel RF infrastructure to provide the required FM radio coverage into KPE and MCE tunnels. The Contractor shall undertake all necessary efforts including tuning and modifications of existing infrastructure to mitigate any potential interference or be interfered by any radio signals inside, outside or adjacent tunnels that may cause confusion to users along the tunnel and tunnel entrances/exits during normal broadcast or during audio break-in.
- 5.6.3 There shall be four (4) FM RBBI tunnels zones within KPE and MCE tunnels, with one (1) zone per bound for MCE tunnel and one (1) zone per bound for KPE tunnel. The FM RBBI system shall be equipped to make broadcasts to specific FM zones or combination of zones of the KPE and MCE tunnels.
- 5.6.4 The new FM RBBI systems in KPE and MCE shall perform continuous self-checks to detect any malfunctions within the MCE and/or KPE FM RBBI systems.

5.7 FM Rebroadcast Facility

- 5.7.1 The FM rebroadcast facility shall include the “off-air” pick-up antenna, associated channel processors, attenuator, etc. for the re-broadcasting of radio station channels into the tunnels.
- 5.7.2 The commercial FM radio channels shall include twenty-two (22) FM radio channels with the centre frequencies from 88.3MHz to 100.3MHz.
- 5.7.3 The FM rebroadcast facility shall be possible to be tuned for rebroadcasting any radio station channels within the respective frequency bands.
- 5.7.4 The FM radio channels may be subjected to further changes and shall be finalized during the design phase. The Contractor shall make the necessary provision for the implementation of the FM rebroadcast facility for the finalized radio channels.
- 5.7.5 Where “off air” re-broadcasting systems are used, provision shall be made for external aerials at locations that permit effective communication. Active radio equipment shall be installed in a position that maximises its ability to receive radio signals “off air” and provides a clear path and minimum distance for the feeder cable connecting it with the radiating cable.
- 5.7.6 All building ‘off-air” and tunnel pick-up antennas shall be installed in a manner with acceptable aesthetic appearance taking maintainability of the antennas into consideration. Mounting design is subject to the acceptance of the SO.

5.8 Audio Break-in Facility

- 5.8.1 The audio break-in facility shall allow the tunnel operator to interrupt the radio re-broadcasts and make announcements to motorists and passengers over their vehicle radios in the KPE and MCE tunnels.
- 5.8.2 The audio break-in may be made through playback of pre-recorded audio messages or by live broadcasts through microphone at new FM RBBI workstation at KPE and MCE OCCs.
- 5.8.3 The audio break-in facility shall allow operators to select individual tunnel zones or combination of tunnel zones for broadcast of pre-recorded messages and “live” broadcast messages.
- 5.8.4 Provisions such as radio receivers and monitoring speakers shall be provided to monitor live FM broadcast and “live” broadcast messages from individual tunnel zones, as well as for playback of pre-recorded messages prior to broadcasting them over the audio break-in facility.

- 5.8.5 In the event that audio break-in messages are disseminated to selected tunnel zone(s) only, audio break-in in the remaining zones shall continue to operate normally and shall not be interrupted.
- 5.8.6 The audio break-in facility shall be able to select pre-recorded audio messages to be announced on all FM station channels simultaneously at the selection of the operator. The audio break-in facility shall be designed and be equipped to support this mode of operation.
- 5.8.7 The pre-recorded messages shall be easily selectable up to hundred (100) pre-recorded audio messages, with a minimum of two (2) minutes message length per message. All pre-recorded messages will be provided by the operator. The Contractor shall convert the pre-recorded messages into a format based on internationally recognised standards (e.g. .wav) acceptable to the SO.
- 5.8.8 The audio break-in facilities shall provide facilities to enable fully digital audio messages recording, easy searches, retrieval, editing and scheduling, etc. The operator interface for the audio break-in facility shall include the following functions:
- (a) Announcement from the microphone;
 - (b) Message (audio) recording/editing;
 - (c) Pre-recorded message selection;
 - (d) Radio channel selection;
 - (e) Interval setting for cycling message (up to sixty (60) mins); and
 - (f) Sequence setting for multiple messages.
- 5.8.9 The new FM RBBI workstation shall provide the following:
- (a) Speaker monitoring facilities to allow monitoring of the audio message announcements;
 - (b) An on-line/off-line control. Messages shall only be transmitted when "on-line" is selected; and
 - (c) Status display of announcements.
- 5.9 New FM RBBI workstation
- 5.9.1 A total of two (2) new FM RBBI workstations shall be provided at each KPE and MCE OCC for control and monitoring of the system. Audio break-in broadcast shall only be transmitted when the new FM RBBI workstation is "online".

- 5.9.2 The new FM RBBI workstation at Main and Standby OCC shall be active at all times. All FM RBBI workstations at Main and Standby OCC shall be active upon login by the operators.
- 5.9.3 The new FM RBBI workstation GUI design and functionalities shall be similar or better than the existing FM RBBI workstation GUI.
- 5.9.4 The new FM RBBI workstation shall be provided with software button (with visual indicators) for the operators to manually activate the switchover function from MCE FM RBBI system to KPE FM RBBI system and vice versa. Proper authentication or password protect function shall be provided to prevent unauthorised or accidental manual switchover.
- 5.9.5 In the event of any malfunctions, alarms shall be activated on the new FM RBBI workstation to inform operators of the failure.
- 5.10 In-tunnel Broadcast Monitoring System (IBMS)
 - 5.10.1 Monitoring facilities, including receivers, in-tunnel feedback antenna(s) installed for the respective tunnel zones and monitoring speaker(s) at the new FM RBBI workstation shall be provided to allow the operator the means to monitor and listen to any FM radio channels (the normal re-broadcast), as well as pre-recorded and "Live" break-in messages being broadcast into the tunnel. This monitoring facility shall be able to monitor each of the tunnel zones.
- 5.11 Coverage and Performance Criteria
 - 5.11.1 The Contractor shall conduct detailed analyses and site surveys to ascertain the viability of his proposed new FM RBBI system design. All detailed analyses and site survey reports shall be submitted to the SO for approval during the final design stage.
 - 5.11.2 The Contractor shall be responsible for all provisions to ensure that FM radio coverage is provided at all times within the tunnels and seamless FM radio reception shall be achieved between the KPE and MCE tunnels and the adjoining surface roads. However, FM radio coverage by the new FM RBBI system shall not spillover beyond the tunnel portals.
 - 5.11.3 All coverage performances are subject to the acceptance of the SO. The Contractor shall perform RF measurements before and after the modification works to verify that the RF signal level and coverage in KPE and MCE tunnels are similar to the existing signal level and coverage. Refer to Appendix B-9 for the existing FM RBBI system signal level and coverage.
 - 5.11.4 The Contractor shall submit detailed link budget calculations, including signal losses in optical transmission, etc. to demonstrate that the

proposed design is able to meet the requirements as specified in this Specification.

- 5.11.5 The Contractor shall ensure that the new FM RBBI system shall not affect the radio coverage of the existing O&M and SCDF radio systems. The Contractor shall carry out all necessary surveys, measurements, adjustments and traffic analysis including the traffic analysis on the existing RF infrastructure as necessary for the implementation of the new FM RBBI system. All surveys, measurements and traffic analysis shall be submitted to the SO for review and acceptance during design stage.
- 5.11.6 The Contractor shall ensure that unconditional simultaneous operation is achieved without noticeable degradation or impairment to the performance of any channel or channels of the new FM RBBI system as a result of the presence of possible inter-modulation or other modes of interference in both the RF reception and transmission stages and communication paths. Such interference shall include the co-channel and adjacent channel interference, carrier and timing errors, non-linearity in combiners and splitters or other factors of the new FM RBBI system.
- 5.12 Interface Requirement
 - 5.12.1 The new FM RBBI system shall interface with the new IVRS for recording of “Live” audio break-in messages of the new FM RBBI system.
 - 5.12.2 The new FM RBBI system shall interface with the new master clock at VB1 and VBD for date and time synchronisation.
 - 5.12.3 The new FM RBBI system shall interface with KPE-MCE ITPMS 2.0 for alarms and operating status management as stipulated in:
 - **Attachment E** of Technical Specification.
- 5.13 Existing Fibre Optic Cables
 - 5.13.1 The existing FM RBBI system utilises the existing FM RBBI system fibre optic cores (from the VBs to the tunnel niches) for connection to the UDAs along KPE and MCE tunnels. The Contractor shall re-use these existing FM RBBI system fibre optic cores for the implementation of the new FM RBBI system as per Appendix B-7. The number of spare fibre optic cores that are available for use by the new FM RBBI system are indicated in Appendix B-8.
 - 5.13.2 Subject to the acceptance of the SO, the Contractor may re-use the existing rooftop cables of the existing FM RBBI systems at VB1 and VBB to receive the FM signals from the rooftop antennas.
- 5.14 Existing IBMS Cables

5.14.1 Subject to the acceptance of the SO, the Contractor may re-use the existing IBMS coaxial cables for the new IBMS in MCE VB1 and KPE VBB for the operation of the new KPE and MCE IBMS.

5.15 Migration Requirement

5.15.1 Prior to the FM RBBI system migration works, the new FM RBBI system including new FM RBBI workstation at OCCs, the new Fibre Optic Master (FOM) and the respective slave units shall be fully tested and ready before starting the FM RBBI system migration works.

5.15.2 The Contractor shall supply all temporary equipment (such as temporary RF switches, RF splitters, etc.) where required to allow for concurrent operation of the existing and new FM RBBI system during migration. The migration and testing of the FM RBBI system shall be carried out in stages until all tunnel amplifiers have been successfully migrated.

5.15.3 Pre and post migration checks shall be performed to ensure that all systems are functioning normally subject to the acceptance of the SO.

6 CLOCK SYSTEM

6.1 General

6.1.1 This section defines the works and requirements for the new Clock System.

6.1.2 The purpose of the new Clock System is to provide time synchronisation for the COMMS and the associated systems as specified in the Specification.

6.1.3 The existing clock system comprises the following equipment installed at the VBs:

Equipment	MCE	KPE
	VB1	VBB
Master Clock	1	1
GPS Receiver with Antenna	1	1
E1 Interface Module	1	1
NTP Server Module	1	1

Existing clock system provides time synchronisation to but not limited to the following existing communications system:

(a) Communication Backbone Network (CBN);

- (b) Ethernet Switches;
- (c) Radio System;
- (d) Ventilation Building Public Address System;
- (e) Tunnel Public Address System;
- (f) Expressway Emergency Telephone System;
- (g) Private Address Branch Exchange;
- (h) Integrated Voice Recording System; and
- (i) Communications Power Supply System.

6.2 Scope of Work

6.2.1 The Contractor shall be responsible but not limited to the following works:

(a) At MCE VB1

- (i) Replacement of existing clock system with new Clock System.
- (ii) Replacement of existing Light Emitting Diode (LED) digital display clock in Main OCC with new LED digital display clock at Main OCC.

(b) At KPE VBB

Removal and decommissioning of the existing clock system and display clock.

(c) At KPE VBD

- (i) Provision of new Clock System.
- (ii) Replacement of existing LED digital display clock in Standby OCC with new LED digital display clock at Standby OCC.

6.3 Concept of Operation

6.3.1 The concept of operation for the existing clock system as well as the new Clock System is indicated / shall be as follows respectively:

	Existing	New
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Clock System	The clock systems at VB1 and at VBB are active at all times and provide time synchronisation for all existing communications sub-systems. When the main clock system fails, synchronisation shall be maintained via the standby clock system	The new Clock Systems at VB1 and at VBD shall be active at all times and shall provide time synchronisation for all existing COMMS, COMMS as well as the SWC systems. When the main Clock System fails, synchronisation shall be maintained via the standby Clock System.
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6.3.2 A summary of new Clock System equipment that shall be supplied by TR413 is specified in Appendix B-1.

6.4 Design Requirement

6.4.1 Each new Clock System shall fulfil the following requirements:

- (a) The master clock source shall have an accuracy of at least Stratum 1 with 1×10^{-11} .
- (b) A redundant Global Positioning System (GPS) clock with an accuracy of at least Stratum 1 with 1×10^{-11} shall be provided as the standby master clock source. In the absence of valid GPS signal, the new Clock System shall operate in free running mode with an internal clock supplying the time signals.
- (c) NTP Servers shall be provided at OCCs to propagate and distribute clock time synchronisation message to COMMS, peripheral devices and their computer-based equipment.
- (d) Probable fault scenarios for the network shall be assessed and suitable synchronisation fallback plans shall be produced.
- (e) Under normal working conditions no slippage shall occur on any interface either internal or external.
- (f) The selection of alternative synchronisation source in the event of network fault shall not require the intervention of the NMS or any manual interventions.

6.4.2 Each new Clock System shall provide all timing output signals required for the synchronisation of the communications system and other systems where required. Each new Clock System shall be capable of supporting the following output sources where required:

- (a) ITU-T G.703 at 2048 Kbits/s;

- (b) IRIG – Inter-Range Instrumentation Group;
- (c) NTP – Network Time Protocol;
- (d) PTP – Precision Time Protocol (IEEE 1588v2); and
- (e) SyncE – Synchronous Ethernet.

The timing signals to be provided shall be determined during project implementation.

- 6.4.3 All GPS antennas shall be installed at locations where sufficient GPS satellite signals can be received for the uninterrupted operation of the GPS receivers and clocks, twenty-four hours a day, seven days a week. Appropriate earthing and lightning protection shall be applied in accordance with SS 551 and SS 555 requirements. Installed GPS antennas shall also be located such that they can be easily accessible for maintenance purpose.
- 6.4.4 In the event of loss of GPS synchronisation signals, the accuracy of the timing signals supplied by the new Clock System oscillator shall be maintained at Stratum 1 (1×10^{-11}) for at least 48 hours. Thereafter the new Clock System oscillator shall maintain a synchronisation accuracy of at least Stratum 2 (1.6×10^{-8}) after the 48 hours period.
- 6.4.5 Upon restoration of the GPS synchronising signal or power supply to the new Clock System, the new Clock System shall automatically synchronise with the GPS timing signals and self-correct, after which only the updated synchronised timing signals shall be transmitted to the display clocks and other systems connected to it.
- 6.4.6 In the event of total power failure to the new Clock System, including failure of internal backup battery, upon restoration of power supply, the new Clock System shall only transmit the corrected re-synchronised timing signals.
- 6.4.7 Each new Clock System shall have at least two spare outputs for each type of synchronisation output provided.
- 6.4.8 Light Emitting Diode (LED) Digital Display Clock
 - (a) At least 1 LED 2-line digital display clock with time, day, and date shall be provided at each Main OCC and Standby OCC. The exact display format, resolution, size and location of the LED digital display clock shall be determined during the design phase and accepted by the SO. The Contractor shall be responsible for the mounting of the display clock at VB1 and VBD OCCs.

- (b) The Contractor shall provide all required mounting accessories for the LED display clock where required.

6.4.9 All design shall be subjected to the SO's acceptance during the design stage.

6.5 Interface Requirement

6.5.1 The new Clock System shall provide synchronisation for all existing communications sub-systems as well as for the COMMS.

6.5.2 The new Clock System shall also provide synchronisation for the following system wide contractor (SWC) systems at the Main and Standby OCC:

- (a) Mechanical Services;
- (b) Electrical Services and Tunnel Lighting System;
- (c) Traffic and Plant Management System (TPMS); and
- (d) KPE-MCE ITPMS 2.0

6.5.3 The Contractor shall provide NTP clock synchronisation (via NTP server at Communications Room (CR)) to all SWC systems. Please refer to **Attachment E** for details on the new Clock System interfaces.

6.5.4 The Contractor shall co-ordinate and support the Employer's maintenance contractor and all SWC to provide any information required for them to configure the necessary clock synchronisation works for all sub-systems in the KPE-MCE operating environment.

6.5.5 Synchronisation with the real-time clock shall not be adversely affected by simultaneous incoming read requests by other systems.

6.5.6 The new Clock System shall interface with KPE-MCE ITPMS 1.0 and KPE-MCE ITPMS 2.0 for alarms and operating status management as stipulated in:

- **Clause 16** of Particular Specification; and
- **Attachment E** of Technical Specification.

The alarm signals for the new Clock System to be monitored shall include the following:

- (a) Loss of GPS signal;

- (b) Failure of master clock;
- (c) Failure of any active new Clock System transmission equipment;
and
- (d) Loss of physical link connection between new Clock System and connected systems.

6.6 Existing GPS Antenna Cable

6.6.1 The existing clock system at VB1 uses the existing rooftop cables to receive the GPS signal from the GPS antenna. The Contractor may re-use these existing GPS antenna cables for the implementation of the new Clock System subject to the acceptance of the SO.

6.7 Migration Requirement

6.7.1 Pre and post migration checks shall be performed to ensure that all Clock System synchronisation are functioning normally subject to the acceptance of the SO.

7 INTEGRATED VOICE RECORDING SYSTEM (IVRS)

7.1 General

7.1.1 This section defines the works and requirements for the Integrated Voice Recording System (IVRS).

7.1.2 The purpose of the new IVRS is to provide centralized record-on-demand automatic voice recording for both digital and analogue voice recording for the COMMS and the associated systems as specified in the Specification.

7.1.3 The existing IVRS comprise the following equipment at the VBs:

Equipment	MCE	KPE
	VB1	VBD
IVRS Server (including Keyboard and Monitor)	1	1

7.2 Scope of Work

7.2.1 The Contractor shall be responsible but not limited to the following works:

- (a) At MCE VB1

Replacement of existing set of IVRS with new IVRS. Refer to Appendix B-1 and Appendix B-14.

(b) At KPE VBD

Replacement of existing set of IVRS with new IVRS. Refer to Appendix B-1 and Appendix B-14.

7.3 Concept of Operation

7.3.1 The concept of operation for the existing IVRS as well as the new IVRS is indicated / shall be as follows respectively:

	Existing	New
IVRS	The main and standby IVRS at VB1 and VBD respectively operates independently.	Shall be similar as the existing operation.

7.3.2 A summary of new IVRS equipment that shall be supplied by TR413 is specified in Appendix B-1.

7.4 Design Requirement

7.4.1 The new IVRS shall be equipped for simultaneous recording of all input channels, including the spare channels when these channels are put into service. Information such as time lapse of recording shall be indicated whenever the recording is in operation. Recordings shall be in digital format. The caller ID of all inputs shall also be recorded.

7.4.2 The new IVRS equipment critical modules such as recording media, power supplies, etc, shall be duplicated; the duplicated set being immediately and automatically set to record should the active set cease to record. Alarm shall be raised during an automatic switch-over.

7.4.3 As a minimum, the new IVRS shall be sufficiently equipped to record all calls simultaneously, and to keep records of all calls for a period of at least 6 months, based on simultaneous and continuous recording of all calls, 24 hours a day, 7 days a week. A minimum of 2 terabytes of storage capacity shall be provided for the new IVRS.

7.4.4 The new IVRS shall be equipped with 30% spare capacity in terms of recording capacity and channels.

7.4.5 The new IVRS shall facilitate flexible and easy replay and review of recorded voice communications at adjustable playback speeds from half speed to two (2) times in not less than 10 steps, with pitch preservation.

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The operator shall be able to replay and review new IVRS voice recorded messages communications locally at the VB.

- 7.4.6 The new IVRS shall provide facility for simultaneous recording and playback operation without affecting the redundancy features of the system.
- 7.4.7 Recording shall be time and date stamped, synchronized with the clock system. Recording shall be traceable to the operator's desk and far end location between which the calls took place.
- 7.4.8 Each voice communications session shall be recorded as individual traceable record without truncation to the voice message. It shall not be necessary for any single voice communications session to be maintained for a minimum duration in order to comply with the aforesaid requirement.
- 7.4.9 The new IVRS shall be able to search and select records through date, time and caller ID.
- 7.4.10 The new IVRS shall provide facilities to archive all records to removable storage media at each CER.
- 7.4.11 All design shall be subjected to the SO's acceptance during the design stage.
- 7.5 Interface Requirement
 - 7.5.1 The new IVRS shall provide recording for all existing voice circuits as indicated in Appendix B-14, except for item (b), where the existing circuit shall be replaced with the new circuits from the new FM RBBI system.
 - 7.5.2 The Contractor shall co-ordinate with Employer's maintenance contractor and provide the necessary interfaces for the recording of items (a), (c), (d) and (e) as indicated in Appendix B-14.
 - 7.5.3 The new IVRS shall interface with the new master clock at VB1 and VBD for date and time synchronisation.
 - 7.5.4 The new IVRS shall interface with KPE-MCE ITPMS 1.0 and KPE-MCE ITPMS 2.0 for alarms and operating status management as stipulated in:
 - **Clause 16** of Particular Specification; and
 - **Attachment E** of Technical Specification.
- 7.6 Existing Audio Recording Cables
 - 7.6.1 The existing IVRS at VB1 and VBD interfaces with the existing audio circuits via the existing IVRS audio recording cables. The Contractor may

re-use these existing audio recording cables for the implementation of the new IVRS subject to the acceptance of the SO.

7.7 Migration Requirement

7.7.1 Pre and post migration checks shall be performed to ensure that all recordings are functioning normally subject to the acceptance of the SO.

8 COMMUNICATIONS POWER SUPPLY SYSTEM

8.1 General

8.1.1 This section defines the works and requirements for the new UPS and new DC rectifiers.

8.1.2 The purpose of the UPS and DC rectifier system is to provide alternative power source for the existing communications system in the event of an incoming mains power failure to sustain the operability of the communications system until the main power source is restored.

8.1.3 The existing UPS and DC rectifier system comprises the following equipment installed at the VBs:

Equipment	KPE					
	VBA	VBB	VBC	VBD	VBE	VBF
UPS	3	4	3	4	3	3
DC Rectifier System	1	2	1	1	1	1

8.1.4 The incoming mains power supply shall continue to supply electrical power to the connected load in the event of failure of the new UPS, or in the event that the new UPS is set to “bypass” mode. Under such circumstances, the connected load shall be able to tolerate the fluctuations in the incoming mains power supply and continue to operate and function correctly and normally.

8.2 Scope of Work

8.2.1 The Contractor shall be responsible but not limited to the following works:

➤ At KPE VBA, VBC, VBE and VBF

Replacement of existing sets of UPS and DC rectifier systems (including DC breakers), complete with the battery bank, with new UPS and new DC rectifier systems (including new DC breakers), complete with the new battery bank, at each VB.

➤ At KPE VBB and VBD

Replacement of existing sets of UPS and DC rectifier systems (including DC breakers), complete with the battery bank, with new UPS and new DC rectifier systems (including new DC breakers), complete with the new battery bank, at each VB.

Refer to Appendices B-15(a) to B-15(b) for the existing power loading of the existing UPS and DC rectifiers.

8.3 Concept of Operation

8.3.1 The concept of operation for the existing communications power supply system as well as the new Communications Power Supply System is indicated / shall be as follows respectively:

	Existing	New
UPS	Each VB UPS operates independently from other VBs.	Shall be similar as the existing operation.
DC Rectifier System	Each VB DC Rectifier System operates independently from other VBs.	Shall be similar as the existing operation.

8.3.2 A summary of new Communications Power Supply System equipment that shall be supplied by TR413 is specified in Appendix B-1.

8.4 Design Requirement

8.4.1 The existing COMMS and COMMS shall be powered by at least 2 hours of back-up battery in the event of mains power failure.

8.4.2 The key elements of the new UPS shall consist of the rectifier, charger, battery bank, inverter, static transfer switch, internal bypass switch and external maintenance bypass switch. It shall be floor mounted with panel type hinged doors with provision for mounting required meters, control switches and accessories.

8.4.3 It shall be possible to perform maintenance tasks for all elements of the new UPS such that there shall be no interruption of power supply to the connected load in all circumstances.

8.4.4 The new UPS shall have at least 30% spare capacity for future expansion.

8.4.5 The new UPS shall provide continuous power supply when input mains power supply is disrupted. When the mains are restored following an

outage, the new UPS shall be able to automatically revert to mains power supply and recharge the battery bank.

- 8.4.6 The overall new UPS efficiency shall not be less than 90% over the range of half rated load to full rated load.
- 8.4.7 The new UPS shall be able to monitor the performance and functionality of all the key elements including rectifier, charger, battery bank and inverter. The monitoring shall include over-voltage, under-voltage and disruption of input power source. It shall be able to provide alarms when pre-determined conditions are exceeded.
- 8.4.8 The new UPS shall be designed and shall be manufactured in accordance with IEC 62040-1, IEC 62040-2 and IEC 62040-3.
- 8.4.9 The rectifier and charger shall be completely automatic and solid-state type having the following features:
- (a) It shall have adequate capacity to recharge the fully discharged battery bank in 16 hours while simultaneously supplying the required input current to the inverter operating at the rated output.
 - (b) It shall regulate its voltage output closely, to regulate the charging rate to the battery for set float or boost charge. The rectifier and charger voltage regulation and control shall prevent the battery electrolyte from reaching too high a temperature, and if required may employ a sensing thermostat attached to one or more cells to lower the charger rate if electrolyte temperature exceeds this normal limit.
- 8.4.10 Rectifier and charger shall be designed with N+1 redundancy and all components shall be hot-swappable.
- 8.4.11 Inverter shall be entirely solid-state type. It shall have a self-protecting current limiting circuit to limit the inverter output beyond 125% full load or for a short circuit at the UPS output terminals.
- 8.4.12 Battery bank design shall be subject to the acceptance of the SO. The following shall be considered:
- (a) Hydrogen gas emission,
 - (b) Battery enclosure shall be constructed of flame-retardant material, and
 - (c) Non-corrodible tray shall be provided.
- 8.4.13 Battery bank shall comprise maintenance free sealed lithium-ion type batteries.

- 8.4.14 Batteries shall operate unearthed. The battery cells shall be fitted with explosion proof vent caps.
- 8.4.15 Static transfer switch shall be provided. It shall automatically switch from inverter source power to the alternate source AC supply input in the event of failure of the new UPS.
- 8.4.16 The new UPS shall be on online UPS. Offline UPS shall only take over within 5ms upon mains failure.
- 8.4.17 The new DC rectifier shall be completely automatic and solid-state type. The new rectifiers shall be designed with N+1 redundancy and all components shall be hot-swappable.
- 8.4.18 All design shall be subjected to the SO's acceptance during the design stage.
- 8.5 Alarm Monitoring
 - 8.5.1 All new UPS and new DC rectifiers shall be supervised and shall provide alarms as well as performance and failure indications in the respective CR.
 - 8.5.2 All new UPS and new DC rectifiers shall be provided with alarm indication panels and shall be able to monitor the performance and operating status of key components, including the rectifier, charger, inverter and battery backup source. Monitoring for UPS alarms shall include power on status, power supply failure alarm, charger fail, over-voltage and under-voltage. Monitoring for DC Rectifier alarm shall include power supply failure alarm. Alarms shall be raised with indications in the respective CR.
 - 8.5.3 Alarms shall include the following:
 - (a) Disruption or failures of incoming main power supply;
 - (b) New UPS and new DC rectifiers failures;
 - (c) Bypass of the new UPS supply;
 - (d) Output voltages drop below and rise above functional levels respectively;
 - (e) Battery charging status;
 - (f) Battery bank failures;
 - (g) Battery discharge alarm; and

(h) High temperature alarm.

8.5.4 The indication panel shall remain visible to maintenance personnel when the rack door is closed. The indication panel shall display information in LCD/LED alphanumeric format.

8.5.5 All new UPS and new DC rectifiers shall also provide visual alerts to maintenance personnel via suitable devices such as LED lamps (to be mounted on the equipment rack) when any of the aforementioned alarms occur.

8.5.6 All new UPS and new DC rectifiers shall be able to generate event and alarms logs with date and time stamp synchronized with the Clock System.

8.5.7 The new UPS and new DC rectifiers shall archive the event and alarm logs for at least 28 days.

8.6 Interface Requirement

8.6.1 The new UPS and new DC rectifier shall interface with KPE-MCE ITPMS 1.0 and KPE-MCE ITPMS 2.0 for alarms and operating status management as stipulated in:

- **Clause 16** of Particular Specification; and
- **Attachment E** of Technical Specification.

8.7 Existing UPS and Rectifier Cables

8.7.1 The existing UPS and DC rectifier system uses the existing electrical cables in the VB CR. The Contractor may re-use the existing electrical cables for the new UPS and new DC rectifier system subject to the acceptance of the SO. Refer to Figures 11-1 and 11-2.

8.8 Migration Requirement

8.8.1 Pre and post migration checks shall be performed to ensure that all power supply systems are functioning normally subject to the acceptance of the SO.

9 NEW SERVERS AND WORKSTATIONS FOR PUBLIC ADDRESS (PA) SYSTEM

9.1 General

9.1.1 This section defines the works and requirements for new servers and workstations for VB_PA and T_PA systems at VB1 and VBD.

- 9.1.2 The purpose of the VB PA system is to provide live and pre-recorded announcements to VBs for OCCs and any other maintenance and operational areas.
- 9.1.3 The purpose of the Tunnel PA system is to provide live and pre-recorded announcements to tunnels and tunnel-associated areas.
- 9.1.4 The existing PA system servers and workstations comprises the following equipment installed at the VBs:

Equipment	VB1	VBD
VB PA System Server	1	
VB PA System Workstation	2	2
Tunnel PA System Server	1	
Tunnel PA System Workstation	2	1

Details of the existing operating system (OS) and application software are provided in Appendix B-12.

- 9.2 Scope of Work
- 9.2.1 The Contractor shall be responsible for the replacement of the existing VB_PA and T_PA system servers and workstations at VB1 and VBD.
- 9.2.2 The Contractor shall liaise with Employer's maintenance contractor for the installation of the existing application software for the new servers and workstations.
- 9.2.3 The Contractor shall be responsible for all provisions such as Virtual Machine (VM) emulator etc., to ensure that the existing application software is compatible with the new hardware (including OS) and no changes shall be required for the existing application software.
- 9.2.4 The Contractor shall reinstate all existing application software onto the new server and new workstation. All reinstated application software shall remain fully functional as the original design.
- 9.2.5 The Contractor shall perform a pre and post functional checks on all the application software to ensure that all its original functions remain fully operational after the migration works.
- 9.2.6 A summary of new PA system equipment that shall be supplied by TR413 is specified in Appendix B-1.
- 9.3 Design Requirement

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- 9.3.1 The Central Processing Unit (CPU) provided for both servers and workstations shall be reliable and robust in construction to perform all the necessary functions to support the VB_PA and T_PA systems .
- 9.3.2 The CPU shall be micro-processor based, completed with adequate disk storage to service the total system requirements and shall be of an industrial standard type, having proven record in similar applications.
- 9.3.3 The operating system for the new servers and workstations shall be based on the latest workable and compatible and proven Microsoft Windows Operating System (OS) or equivalent.
- 9.3.4 Unless otherwise specified, the new servers shall meet the following minimum requirements:

Server Specifications	
Memory	16 GB or higher
Storage	2 TB or higher
Graphics Processing Unit (GPU)	Intel® Iris® Xe Graphics or better
USB Port	At least 4 ports
HDMI Port	At least 1 port
Workstation Accessories	19" Display Monitor USB Keyboard and Mouse

- 9.3.5 Unless otherwise specified, the new workstations shall meet the following minimum requirements:

Workstation Specifications	
CPU	Intel® Core™ i7 or higher
Memory	16 GB or higher
Storage	1 TB or higher
Graphics	Intel® Iris® Xe Graphics or better
USB Port	At least 4 ports
HDMI Port	At least 2 ports
Workstation Accessories	24" Display Monitor USB Keyboard and Mouse

- 9.4 Migration Requirement
- 9.4.1 Pre and post migration checks shall be performed to ensure all PA new servers and workstations are functioning normally subject to the acceptance of the SO.

10 CABLE AND CABLE SUPPORT SYSTEM

- 10.1 Unless otherwise accepted by the SO or unless otherwise required for the Works stipulated under this Specification, the Contractor shall make

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provision for new cables and new cabling support system where required for the works as stipulated in this Specification.

- 10.2 All new cables and new cable support system shall be provided with a minimum of 30% spares.
- 10.3 Cables
 - 10.3.1 The Contractor shall be responsible for all cable termination and fibre optic termination and splicing works for the Works.
 - 10.3.2 For existing cables that are re-used, the Contractor shall verify the condition of these existing cables and determine if it is suitable for re-use. The Contractor shall co-ordinate with the Employer's maintenance contractor and the SO on the re-use of these existing cables as specified in this Specification. Any re-use of the existing cables shall be subject to the acceptance of the SO.
- 10.4 Cable Support System
 - 10.4.1 Cable support systems shall include all types of cable trays, trunkings, conduits and any other cable support systems for supporting or mounting cables.
 - 10.4.2 For existing cable support systems that are utilised, the Contractor shall verify the space availability and determine whether sufficient space is available for the Works. The Contractor shall co-ordinate with the Employer's maintenance contractor and the SO on the utilisation of these existing cable support systems as specified in this Specification. Any utilisation of the existing cable support systems shall be subject to the acceptance of the SO.

11 ELECTRICAL REQUIREMENT

- 11.1 General
 - 11.1.1 The Contractor shall be responsible for the complete design, supply and provision of the electrical works for the complete delivery and operation of the COMMS as specified in the Specification.
 - 11.1.2 The Contractor shall ensure that his electrical design and installations are in compliance with the regulations of Singapore Power.
 - 11.1.3 All electrical installations shall comply with SS 638 and regulations of the Energy Market Authority (EMA). All electrical designs, installations and associated drawings shall be endorsed by Licensed Electrical Worker (LEW) or Qualified Person (QP) of the appropriate grade.

- 11.1.4 System equipment, assemblies and units shall be appropriately earthed. Earthing designs shall conform, where appropriate, to Singapore Standard (SS) 551 Code of Practice for earthing. Lightning protection designs shall conform to SS 555.
- 11.1.5 The Contractor shall modify the existing Distribution Boards (DB) and electrical systems (where required) to provide the necessary electrical needs for the Works. This shall include any associated modifications, provisions, cables and electrical terminations, etc. which shall be the responsibility of the Contractor.
- 11.1.6 Where required for the Works, the Contractor shall provide DBs, including all necessary cables, conduits and fixings to provide the power supply for the COMMS.
- 11.2 Scope of Work
- 11.2.1 The Contractor shall be responsible but not limited to the following works:
- (a) Provide all necessary electrical work for the COMMS as specified in the Specification.
 - (b) Conduct site surveys to verify the accuracy of the existing electrical diagrams and information provided in this Specification.
- 11.2.2 The Contractor shall provide design submissions, drawings of the electrical requirements, specifications, and connections for the communications system, for the SO's approval. This shall include detailed calculations, breakdown and distribution of the power requirements for the works in the design submissions.
- 11.2.3 The Contractor shall engage its own PE and LEW for all necessary electrical works. The Contractor shall ensure that all drawings and relevant information for the works and submission to the Authority have been endorsed by the PE and LEW. All subsequent revisions to these drawings or information and new drawings shall also be endorsed by the PE and LEW. All drawings and other relevant information issued to the SO for acceptance is subject to the final acceptance of the SO.
- 11.3 Interface Requirement
- 11.3.1 The Contractor shall interface with the Employer's maintenance contractor on all power supply requirements for the complete delivery of the COMMS equipment. High-level logical diagrams showing the electrical interface boundary for KPE and MCE are provided in Figures 11-1 and 11-2 below.

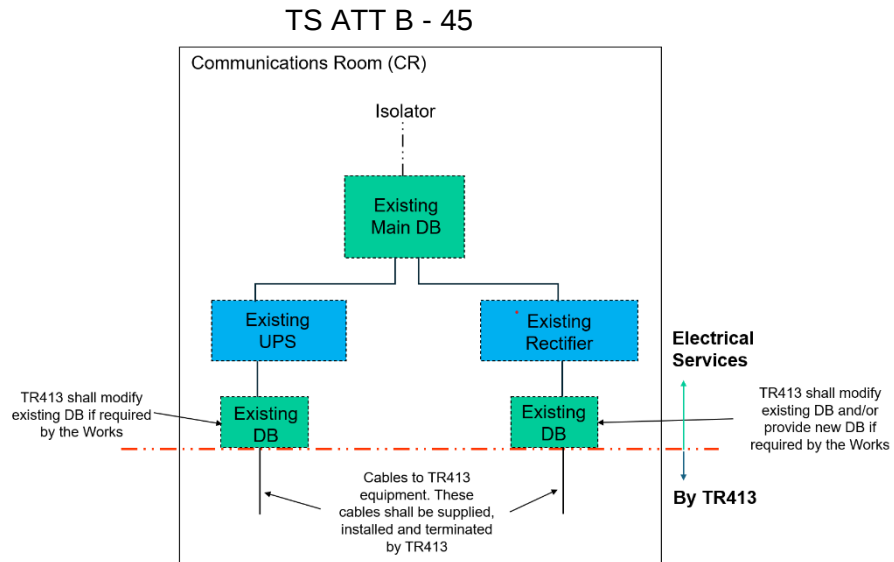


Figure 11-1 Interface Boundary for VB1 and VB2

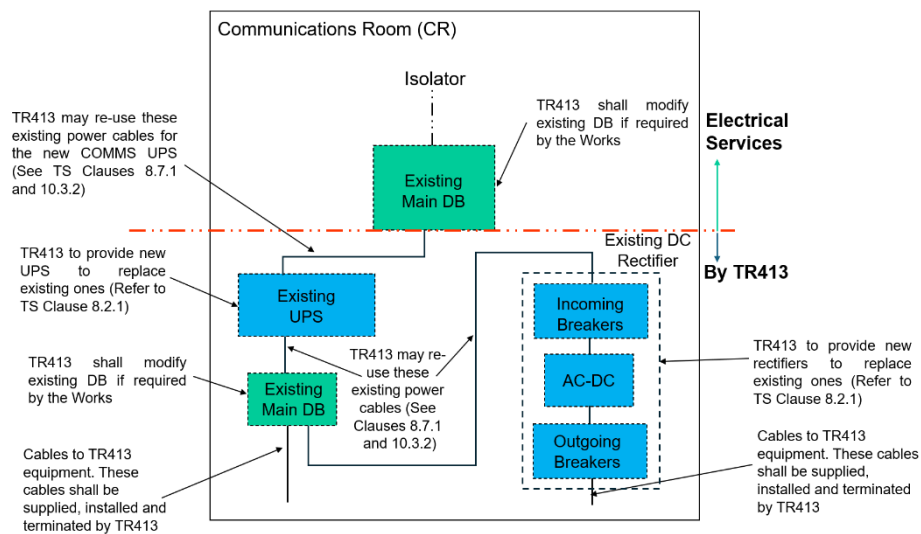


Figure 11-2 Interface Boundary for VBA, VBB, VBC, VBD, VBE and VBF

- 11.3.2** The Contractor shall be responsible for all power distribution works and provide the updated electrical single line diagram for the COMMS equipment at KPE and MCE.
- 11.3.3** The updated electrical single line diagram shall be endorsed by LEW. The endorsed diagram shall be inserted in the metal pocket on the inner side of the panel door of the existing DB. Refer to Appendix B-17 on the availability of the existing communications system DB spare breakers for the Works.